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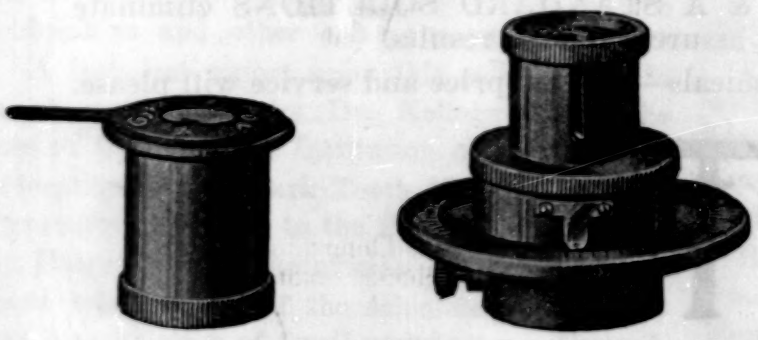

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THE ORIGIN OF THE CYCADS[1]

THE widest gap in the evolution of plants used to be the one between the ferns and seed plants; but the researches of the past thirty years have bridged the gap so completely that the two groups are now separated only by the artificial definitions of the taxonomist.

The Cycadofilicales, which our British friends prefer to call the Pteridosperms, are the bridge. They looked like ferns and were naturally mistaken for ferns; and there is no doubt that their immediate ancestors were heterosporous ferns which had gradually developed the seed habit.

The forms already discovered have seeds much larger than the sporangia of any known heterosporous fern and almost as highly developed as those of the living Gymnosperms; but when the more primitive members shall have been discovered, we predict that the seeds will be comparatively small, developing from small ovules, containing still smaller female gametophytes, which will have little free nuclear division, or even none at all.

But the forms already discovered have the characters necessary to qualify them as the ancestors of the rest of the cycadophyte line; that is, the "fossil cycads" of the Mesozoic, more precisely known as the Bennettitales, and the living cycads, the Cycadales.

That the Paleozoic Cycadofilicales have given rise to the Mesozoic Bennettitales, or "fossil cycads," is practically certain. Researches upon the Paleozoic forms, especially by British botanists, and the magnificent researches of Wieland upon the Mesozoic Bennettitales have established this connection beyond any reasonable doubt. These Bennettitales were called "fossil cycads" because they were supposed to be the ancestors of the living cycads.

The living cycads, with one family, nine genera and about one hundred species, form a natural assemblage; but their geographic distribution, as well as their morphological characters, make it evident that the various genera have been separated for a long time, perhaps during most of the Mesozoic.

Dioon, with three species, is probably confined to Mexico.

Ceratozamia, with two species, may also be confined to Mexico. It has been reported beyond the

[1] Address of the vice-president and chairman of Section G—Botanical Sciences—American Association for the Advancement of Science, Washington, D. C., December, 1924.

southern boundary but, so far as I have been able to find out, there is no evidence that the plants were growing wild.

Microcycas is even more restricted, being confined to Cuba.

Zamia, with more than a third of the species of the whole family, has a wider range, the numerous species being scattered from Florida, Mexico and the West Indies, down the Andes to Chili.

These four genera are confined to the western hemisphere; and all except *Zamia,* and even most of its species, lie north of the equator.

The other five genera belong to the Oriental tropics. Encephalartos, with sixteen species, is confined to South Africa. *Encephalartos latifrons* may be the slowest growing of all the cycads. It is found only in the extreme southern part of South Africa.

Encephalartos caffer has the largest cone ever developed by any plant; fifty pounds is a common weight and ninety-three pounds has been reached. *Encephalartos Altensteinii* is the most popular species in cultivation.

Stangeria, with only one species, is also confined to South Africa. It is not surprising that it was classed with the ferns until the cones were discovered.

Macrozamia, with sixteen species, is confined to Australia. Some of the species, like *M. spiralis,* have subterranean stems; while others, like *M. Moorei,* have well-developed trunks.

Bowenia, with only two species, is even more restricted in its range, having been found only in the northeastern part of Australia.

The eighteen species of *Cycas,* the remaining genus, are scattered from Japan down through the various islands to New South Wales in Australia.

So all the oriental genera, except *Cycas,* are south of the equator. All the living genera are tropical or subtropical, and no genus is common to the eastern and western hemisphere.

However, in the Mesozoic, the geographical distribution was probably more extensive; and it is suggestive to note that the fossil Zamites of South Africa might very well pass for the impression of a living leaf of a Mexican *Dioon edule.*

What could have been the origin of this group, now so scattered and limited in distribution?

Many years ago, a noted botanist, in a paper on nuclear and cell division, said that the achromatic structures came from the nucleus or from the cytoplasm or, possibly from both. Thus, no matter what might be proved in the future, he was in position to claim priority.

Similarly, in case of the cycads, it may be that every extinct race of plants has been called upon, at one time or another, to function as their ancestor. Consequently, it would be impossible to suggest an entirely new origin, unless some entirely new race of fossil plants should be discovered.

We believe it safe to assume that the cycads could not have come from the lycopods or from any group with lycopod affinities; or even from any group in the Coniferophyte phylum. The cycads must have come directly or indirectly from the ferns. There are three possibilities: They may have come directly from the Filicales, or they may have come from the Cycadofilicales or they may have come from the Bennettitales.

In regard to the Filicales, or ferns, little need be said. During the Devonian, especially the upper Devonian, heterospory must have been developing with increasing frequency; for some ferns had already reached the seed condition before the end of that period; and during the Carboniferous, the seed ferns, the Cycadofilicales, may have outnumbered the true ferns. During the transition from homospory to heterospory and from heterospory to the seed condition, the leaf and stem remained practically unchanged, so that it was very natural to mistake these early seed plants for ferns.

The transition must have been gradual and it doubtless followed the line indicated by the ontogeny of the living heterosporous ferns. As megaspores became larger and larger, development would proceed farther and farther before the spores were shed; until, finally, a time would come when the megaspores would not fall out from the sporangium. Then, by definition, the sporangium with its contained megaspore would be a seed, and the plant would belong to the Gymnosperms.

That the Bennettitales have come from these fern-like Gymnosperms of the Paleozoic can hardly be questioned; but whether the living cycads have come directly from the same source, or have arisen later from the Bennettitales, possibly from some very low and still undiscovered members of that order, may still be a subject for discussion. We believe that the living cycads have come, like the Bennettitales, directly from the Cycadofilicales, the fern-like Gymnosperms of the Paleozoic.

Of course, whole plants of these Carboniferous forms, with roots, stem, leaves, stamens and seeds all in place, have never been discovered and we do not even hope to see them: but the parts have been found separately —a leaf attached to its stem, a seed still attached to a leaf—so that we are able to reconstruct the plant with reasonable accuracy, and to refer loose seeds to the proper plant, just as one refers a hickory nut or a chestnut to the tree from which it came. Putting various well-known parts together, we can reconstruct a hypothetical ancestor which could have given

rise to both the Bennettitales and the Cycadales. A female sporophyll of the Pecopteris type, with male sporophylls, foliage leaves and trunk of types so common that they caused the Carboniferous to be called the "Age of Ferns," will serve for a start.

Beginning with such a hypothetical, but very possible and even probable ancestor, both the Bennettitales and Cycadales could be developed.

The pinnate leaves of the fern has been retained throughout the entire phylum. It is more than doubtful whether the three orders can be distinguished by the leaves. The leaf impressions of some of the Mexican Bennettitales, like *Ptilophyllum acutifolium* and *Pterozamites angustifolium,* so thoroughly described and illustrated in Wieland's "Flora Liassica," can hardly be distinguished from *Dioon,* which now flourishes in southern Mexico: and the leaf impressions of the African Zamites, as already indicated, also bear a close resemblance to the leaf of *Dioon,* although neither *Dioon* nor any other cycad with a similar leaf is now living in Africa.

The stem throughout the phylum has a large pith, scanty zone of wood, a fairly large cortex and, with exceptions, an armor of leaf bases.

The histological structures should not be overlooked. In the Cycadofilicales the stem is, prevailingly, a mesarch siphonostele; while in both the Bennettitales and the Cycadales it has advanced to the endarch condition, with the mesarch condition still appearing in the seedlings of Cycadales and, probably, in those of the Bennettitales as well.

In the Cycadofilicales the wood, in most cases, is composed of tracheids with bordered pits, a condition more advanced than that in the ferns, which are characterized by scalariform tracheids. Since ferns scarcely ever get beyond the scalariform tracheid stage, we should expect to find the lowest members of the Cycadofilicales characterized by scalariform tracheids. Since the wood of the Bennettitales is composed almost exclusively of scalariform tracheids, the order must have come from forms lower than the known forms of Cycadofilicales, which have already reached the pitted tracheid stage.

Most of the Cycadales have reached the pitted tracheid stage of development, although the scalariform tracheid is still prevalent in the metaxylem; and in the fern-like *Stangeria* the scalariform tracheid is still retained even in the secondary wood.

On the whole, the vegetative structures of the Bennettitales and Cycadales show an advance over those of the Cycadofilicales; and the evidence seems conclusive that the Bennettitales have come from the Carboniferous Cycadofilicales. But whether the Cycadales have come from the Bennettitales, or have come directly from the Cycadofilicales, is a question which could not be answered by the vegetative structures; at least could not be answered without an intensive study of the vegetative structures of all three orders.

But when we turn to the reproductive structures, the evidence is more decisive, in our opinion conclusive, that the Cycadales have not come from the Bennettitales, not even from the lowest members of this order, but have come directly from the Cycadofilicales.

None of the Carboniferous Gymnosperms of this phylum had attained the cone condition. The leaves bearing male sporangia and those bearing female sporangia were still in loose crowns, bearing more or less resemblance to the crowns of vegetative leaves, but were becoming reduced in size and there was a strong tendency to simplify the outline, just as we see both of these tendencies in the spore-bearing leaves of many of our living ferns. Naturally, the original axis would persist throughout the life of the plant, for the crowns of spore-bearing leaves would fall off just like crowns of foliage leaves.

The Bennettitales would develop naturally from such an ancestor. A progressive reduction of the lateral pinnae of the female sporophyll would finally result in the production of a single seed on a slender stalk, with no trace of leaflets along the sides. As the sporophylls became smaller, they became more numerous and became compacted into a tight cone. Many of the sporophylls lost not only the lateral pinnae, but even the seed at the top, becoming entirely sterile and functioning only as protective structures.

The male sporophylls were much less modified. Even in the most advanced members of the Bennettitales they continued to appear in loose crowns and retained more or less of the characters of the pinnate leaves.

The origin of the Bennettitales from the Cycadofilicales is so obvious that, as far as we know, it is not disputed. There might be different views as to the mode of origin, but hardly as to the origin itself.

In our opinion, it is even more obvious that the Cycadales also have come from the Cycadofilicales. In this case, the upper part of the female sporophyll has become sterile, while the lateral ovules have persisted. *Cycadospadix Hennoquei,* in the Lias, shows this type; but this ancient sporophyll had already diverged farther from the foliage leaf than has the living *Cycas revoluta.* A still wider divergence is shown by *Cycadospadix Milleryensis,* in the Permian, which shows the type of cone we should anticipate if the living *Cycas tonkinensis* should group its crown of sporophylls into a cone. Since this type is more advanced than the preceding, the Cycas type

must have been differentiated very early, probably in the Carboniferous. We believe that these sporophylls belong to the Cycadales, and that from this point there has been a reduction of the pinnate leafy top, while the ovules remained lateral.

If the Cycadales have come from the Bennettitales, the connection would have to be between the lower members of both groups; but even in the Triassic, and probably much earlier, the Bennettitales had already lost their lateral pinnae and had become established in the terminal ovule habit. As far as age is concerned, one order seems to be as old as the other.

My friend, the late Samuel Williston, used to say that, phylogenetically speaking, when a tooth is lost, it is lost for good. We accept as a fundamental principle, proved by paleontologists, especially vertebrate paleontologists, that when a structure has been lost during phylogeny, it can not be regained. The horse of to-day will never regain the toes it kept losing during the Oligocene, Miocene, Pleiocene and Pleistocene. The phenomenon known as reversion, or atavism, is effective over too short a period to be of much interest to the vertebrate paleontologist or the paleobotanist. The horse of to-day does not revert to a five-toed race of horses; and, in accordance with the same fundamental principle, we believe that the female sporophyll of the Bennettitales, having lost its lateral pinnae, lateral ovules and leafy top, could not have given rise to the primitive sporophyll of the Cycadales, in which these lost characters are dominant.

If the case is proved for the female sporophyll of the Cycas type, it is proved for the whole group; for within the living members of the Cycadales, the development of the compact cone from a loose crown of sporophylls can be traced with confidence.

In the genus *Cycas* itself, the various species show a reduction of the pinnate, leafy top, and the ovules become reduced to a single pair which characterizes all the other genera. In *Dioon edule* the female sporophylls have lost practically all the pinnate character, but still retain something of the topography of the foliage leaf, and they are grouped into a loose cone, which looks as if it might proliferate; for even compact, staminate cones sometimes show a little proliferation.

In other genera the reduction becomes more and more pronounced. In *Macrozamia* the midrib of the sporophyll persists as a long spine, with occasional traces of the lateral pinnae; in *Ceratozamia,* two of the lateral pinnae remain as strong spines; in *Encephalartos* both midrib and pinnae have been lost, although there are traces of lateral pinnae in some species. In the highest genera, like *Zamia,* even such occasional slight traces of pinnae have disappeared, and only its origin and nature entitle the ovule-bearing structure to be called a sporophyll.

We believe the evidence shows that the Cycadales are not a branch from the Bennettitales, but that they have arisen directly from the Cycadofilicales. The Cycas type was probably differentiated during the latter part of the Carboniferous, and some of its forms soon advanced to the cone type, while others remained at the Cycas level and are represented to-day by the genus *Cycas.* However, it is not necessary to assume that all the genera with the female sporophylls in cones were differentiated at such an early period; for cones like those of *Dioon* and *Stangeria* might very well have been developed from the *Cycas* type at a much later period.

The strongest objection to our contention is the scarcity of fossils in the Mesozoic, which can be referred, positively, to the Cycadales. Throughout the period there are leaves to which the Cycadales have as good a claim as the Bennettitales. The cycad leaf is tough and leathery and well suited to preservation; but the female sporophylls of the Cycas type, and all cones, soon decay, so that the chances for their preservation are slight. The condition is very different from that in the Bennettitales, whose well-protected cones are in a very favorable position for preservation.

The scarcity of fossils, especially any scarcity in the Cretaceous and Tertiary, is not such a strong objection, when we remember that living cycads are all tropical and subtropical, and that more than half belong to the southern hemisphere; while fossils have been hunted and studied principally in the university zone of the northern hemisphere. And the objection is weakened still further when we remember that probably more than half of our knowledge of the Bennettitales has come from the enthusiastic researches of one man. Wieland goes to a new place, and we have the "Flora Liassica." And now the textbooks can say that the lower Mesozoic of southern Mexico is very rich in fossils of the lower Bennettitales.

If four or five Wielands should search for fossils throughout the Carboniferous, Permian, Mesozoic and Tertiary, in both the northern and southern hemispheres, our knowledge of the facts would not long remain so fragmentary. We should have facts instead of inferences.

We have confined ourselves almost entirely to a discussion of the macroscopic structures. In the living cycads the microscopic details are fairly well known: the microscopic structure of the sporophyte, the development of the gametophytes, with the details

of oogenesis, spermatogenesis, fertilization and embryogeny, have been described rather thoroughly in some forms and have been outlined in others. The swimming sperm, a fern character, is still retained by all the living genera; but the development of the archegonium is more advanced than in *Pinus*. The embryogeny is more primitive than in any known forms of the Coniferophyte phylum. While these features are of great importance in deciding the interrelationships of the living genera, they could not have much value in determining the origin of the cycads, unless we could learn corresponding details of Mesozoic and Paleozoic forms. What some of these details must have been, we can hazard a guess. The seeds of the living cycads are large, some of them reaching six centimeters in length. In such a seed, the female gametophyte is large, with large archegonia, the pollen tubes are long and there is an extensive free nuclear period in the embryogeny. No Mesozoic seeds in either Cycadales or the Bennettitales even approached the size of the seeds of some species of *Cycas* and *Macrozamia*. Consequently the female gametophyte must have been smaller, with smaller archegonia and probably a shorter free nuclear period in the embryogeny. The pollen tube must have been shorter and may have contained many sperms. In the Bennettitales, with their very small seeds, the female gametophyte must have been very small, with little free nuclear division, extremely small archegonia and, perhaps, no free nuclear stage in the embryo. Pollen tubes were either very short or entirely lacking. In the Paleozoic Cycadofilicales, with many of the seeds smaller than those of the Bennettitales, there were no pollen tubes, and in the earliest seeds the conditions could not have been much more advanced than in some of the living species of *Selaginella*. While these structures may seem visionary, they are about what we should expect to find, as we go from large seeds to smaller and smaller ones, if the same kind of differences which we see in the larger and smaller seeds of the living cycads are continued in the still smaller and smaller seeds of the Mesozoic and Paleozoic forms of the same phylum.

While we believe that microscopic details, if available, would be of even greater value than the macroscopic in tracing relationships, we feel certain that the facts already known prove that the Cycadales have come from the Cycadofilicales and that the differentiation of the two groups may have occurred long before the end of the Carboniferous.

CHARLES J. CHAMBERLAIN
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"AGE AND AREA" IN RELATION TO EXTINCTION

THERE are few generalizations in regard to the geographical distribution of species which have aroused so much interest and elicited so much criticism as the theory of Age and Area of Dr. J. C. Willis. I think it must be admitted that the laborious statistical researches of this investigator have established a fairly definite relation between the number of related endemic species in a given region and the areas which the several species occupy. Willis finds that species of wide distribution are relatively few in number; species whose range is less wide are more numerous, and species which are much restricted in area are most numerous of all. According to the Age and Area theory the "wides" are on the average the oldest species, the small area species being in general those of recent origin which have not had time to spread widely. Dr. Willis believes that under normal conditions species extend their range very slowly, and hence if a species has a wide distribution it must have been in existence for a great length of time. In a very broad and general way this contention is probably right. It is not entirely evident, however, that the species of narrow range are nearly all young, although Dr. Willis has advanced many arguments against the common view that they are species approaching extinction. In general, and so far as is permitted by barriers, the range of a species, according to Willis, is determined not by natural selection or any other agency making for adaptation, but in a more or less "mechanical" way as the result of mere age. "The real difference," he tells us, "between the old view of dispersal and that given by Age and Area is that under the latter we regard *almost all* species as in process of extending their areas of dispersal, not some as extending their areas and as many or more contracting theirs. The exceptions to this—the real relics—are comparatively few and far between, forming perhaps 1 to 2 per cent. of the total of species of very restricted area."[1]

The idea that species are almost all on the spread, and that the process of extension goes on in a "mechanical" fashion leads Willis to set little store by the struggle for existence and selective survival as factors in the distribution of life. "The struggle for existence," he tells us, "can no longer be regarded as an important determining cause in evolution." It acts most strongly in species that are "just commencing." "If they can not succeed in this first struggle they will simply die out and leave no trace. But if they do succeed, they may be looked upon as estab-

[1] "Age and Area," Cambridge, 1922.

lished, for they will be very liable to sudden extermination whether ideally or badly equipped for life."

I am not concerned now with this somewhat curious way of looking at the struggle for existence. Dr. Willis draws rather far-reaching conclusions in regard to the potency of natural selection as a result of his views on the relationship of area of distribution to age. He has established certain principles to which numerous facts of distribution conform, and in doing this he has performed a notable service to this field of scientific inquiry. His doctrine of Age and Area is an attempt to explain the relationships he has established, and it is of course possible that these relationships may be interpreted in some other way. I believe, moreover, that the theory of Age and Area contains a large element of truth, although I am equally convinced that the relations discovered by Dr. Willis are not nearly so damaging to the theory of natural selection as the author imagines. Although Dr. Willis reminds us that "very strong evidence, and evidence based upon definite facts, not upon *a priori* reasoning, is now required to show that the hypothesis of Age and Area is unsound," I am nevertheless impelled to give expression to some doubts in regard to the general validity of the Age and Area theory. It is with some hesitation that I venture to discuss the conclusions of a worker who has devoted years of study to a field in which I have made no original investigations, but an endeavor to understand Dr. Willis's theory and to think out its logical implications has suggested several inherent difficulties of this interesting speculation. I could not help asking myself if it were, in the nature of things, possible for nearly all small area species to be young and expanding, for this would naturally mean that species come into existence very much more rapidly than they disappear. Doubtless there has been a slow increase in the number of species of plants and animals throughout geological time, but the lifetime of a species is in most cases much less than the duration of a geological period. A few genera last through several periods, but they are quite exceptional, and long-lived species are still more exceptional. If we take a date in geological history, say the beginning of the Miocene, it is evident that most species that originated up to that time are now gone. If we may judge from the past history of life on this globe, we must conclude that at some future time as remote as the present is from the Miocene, most of our present species will be extinct and replaced by new forms. There is no gainsaying the fact that with the exception of species now living on the earth (and these are a very small fraction of the total number of species existing at some time) all the species that have arisen have also died out. Age and Area, as conceived by Willis, requires a world which is in process of being stocked with new species, and not one in which old species go out about as fast as new ones come in. If species die, and dwindle before they die, a good many small species must be relics. But this conclusion Dr. Willis refuses to admit. Of course some Cuvierian cataclysm might suddenly wipe out a whole fauna and flora, but this is not the usual process of extinction. There are records of many species that have become extinct, usually through the agency of man, and in almost all cases rarity precedes extinction, although the disappearance of the species may be more rapid than its initial spread. I do not think we know enough about the extinction of species under natural conditions which have not been altered by the meddling of man to be able to say whether the contraction of range which precedes the disappearance of a species is in general more or less rapid than its previous expansion. In any region there are a few wide-ranging and possibly old species, more of narrow range which are perhaps younger, and still more of smaller area; but why should we assume that the small species are spreading? Why may they not be both young and contracting? Not many, we may concede, are the remnants of previous wide-spread forms, but quite a few may be old species which have never been widely spread, the occupants of some peculiar ecological niche to which they are especially adapted. I can not help thinking that Dr. Willis has unduly minimized the rôle of extinction and has gotten himself into a logically untenable position, although it is one from which he may retreat without entirely abandoning his fundamental principle. Most "wides" may be old, and a large proportion of small area species may be young, but it does not follow that nearly all are marching steadily on toward a larger place in the sun.

I have looked through many of Dr. Willis's writings to find if the foregoing rather simple considerations that have troubled me have also troubled him, but I can find no adequate discussion of the situation. On reading his paper on the Endemic Flora of Ceylon,[2] one might infer that Willis fully considered the situation I have presented. In discussing a curve illustrating the origin, spread and extinction of species he says:

> Ultimately each species will reach a maximum height in the curve. It may stay there a long time, or may go up and down with the appearance on the scene of new factors affecting it. But as a good many of the newer species which come into being and climb the curve will tend to be a little better adapted than those that preceded them, we may take for granted that in the great

[2] Phil. Trans. Roy Soc. London. B. 206, p. 307. 1915.

majority of cases the species, however high it may have climbed, will ultimately begin to descend.

This is eminently sensible. On the next page, however, there occurs a footnote to the effect that "in a subsequent paper it will be shown that there is little evidence that any species are dying out." This note appears to have been added in a sort of afterthought, as if he had repented him of what he had said and concluded that he had conceded too much. I do not know what the subsequent paper is to which Dr. Willis alludes, but in an article on "The evolution of species in Ceylon, with reference to the dying out of species," published in January of the following year (1916),[3] it is stated quite definitely that "species, or at least the majority of them, do not appear to die out except by accident," and that "there is no evidence whatever that any of the angiospermous species of the Ceylon flora are dying out, and from analogy we may imagine this to be generally true." In a somewhat later paper[4] he says:

> The figures given in my various papers on this subject afford no evidence to show that any species are actually dying out. Many people at once jump to the conclusion that by this I mean that *no* species are dying out, but this is by no means the case. What the figures show is that such cases are too few to be seen in them in an unmistakable way.

These extracts and the later ones previously quoted seem to indicate that Dr. Willis has developed an increasing reluctance to admitting that species normally die out, although he rather grudgingly concedes that they may do so on rare occasions. As he has engaged in more or less controversy as to whether small area species are youngsters or relics, possibly this reluctance is one of the psychological effects of opposition, a sort of defense reaction which he has adopted in the course of supporting his argument. I confess that I can not see the logic of his position, and am led, therefore, to seek for psychological reasons for understanding why he has adopted it. Surely Dr. Willis does not expect species to last indefinitely. Does he seriously think that we are living in a geologically unique period in which species are being born many times as fast as they die? Does he believe that species are usually "killed out" by some sudden catastrophe? Or has he simply been led, through his opposition to the notion that small area species are relics, into defending an extreme position that is inherently inconsistent?

There is also another consideration that troubles me, although I admit that it is largely *a priori*. Suppose we have several species extending their range. Must not this extension be generally at the expense of some other occupants of the territory whose range becomes correspondingly restricted? The plant and animal life of any region is precariously near the saturation point, and it is absurd to suppose that species in it can expand and expand according to Age and Area without causing some other unfortunate species of the region to retire. One naturally thinks in this connection of the classical examples of the European cockroach being driven out by its Asiatic relative, and the native Australian honey bee retreating before the successful invasion of the common hive bee. With closely allied species (and it is to such that the Age and Area principle is supposed especially to apply) there is commonly acute rivalry, and the spread of one species naturally involves the retreat of another. It seems fairly evident to my *a priori* point of view that, under usual conditions, expansion and being squeezed into smaller limits are correlative phenomena, and that the two processes go on at approximately the same rate.

Sometimes, it is true, species overlay and intermingle; but in so far as closely allied forms obey Jordan's law, and they do so quite generally among the higher vertebrates and presumably also in many other groups less closely studied, they seem to constitute mutually exclusive aggregates. In any case, even when expansion goes along with interpenetration, there is antagonism and a tendency of one species to squeeze out the other. The doctrine that most small area species are relics of previously widespread forms is probably not tenable, but there is nothing in Dr. Willis's statistical data to preclude our regarding many of them as relatively young species which are gradually succumbing to pressure. This is, I believe, a very important point, especially in relation to the objections Willis has raised in regard to the efficacy of natural selection. When an attempt to make what Professor Tyndall calls the scientific use of the imagination in order to see where Dr. Willis's theory of species forming takes us, we find that we are led to a *reductio ad absurdum*. The theory at least requires modifications to bring it into harmony with the facts of extinction and the shrinkage of area which precedes extinction. When these modifications have been made I suspect that several of Dr. Willis's criticisms of natural selection, especially so far as they are based on the assumption of a regular mechanical tendency of species to spread, will fall to the ground.

S. J. HOLMES

UNIVERSITY OF CALIFORNIA

BERKELEY, CALIFORNIA

[3] *Ann. Bot.* 30, p. 1. 1916.

[4] *L. C.* 31, p. 335, 1917.

ALFRED HULSE BROOKS[1]

JULY 18, 1871–November 22, 1924: Not a long life as we count years, but a rich life as we weigh results.

Born in Michigan, Alfred Brooks spent his youth in New York, Georgia and Germany. His seventeenth birthday found him already doing field work as a topographic assistant in the United States Geological Survey, and on his graduation from Harvard he was appointed an assistant geologist, one of that group of Harvard graduates who brought so much of strength and enthusiasm to the Survey in the early 90's.

The one word that best describes Alfred Brooks is loyal: he was loyal to those he loved—his family and his friends; he was loyal to his science and to the organization of which he was a member for thirty years; he was loyal to his chosen field of activity and to his country. This unswerving allegiance, the outstanding trait of the man, translated itself into abiding friendships, devoted service and effective patriotism.

Among his associates Alfred Brooks made friends and kept them. He was honored and admired the whole length and breadth of Alaska; his fellow geologists can testify to the high regard in which those who knew him longest and best will hold his memory. He was the associate to whom I, like others, turned most frequently for wise counsel and frank criticism.

As a geologist, Alfred Brooks sought his ideals in his own way. He had a genius for truth, and his loyalty to scientific truth made pretense impossible, although his unfailing humor often concealed his real contempt for any effort to make science appear what it is not. His service to pure science was not a lip service.

His loyalty to the United States Geological Survey differed not in quality from that to his family, his friends and his science. He gave his best, without stint and at sacrifice of health. His spirit as a worker was to give without thought of return; the unselfishness of his service is well shown by the fact that although the scientific leadership of the Geological Survey, the position of chief geologist, was twice offered to him, each time, while expressing his willingness to obey orders, he urged the selection of another as better fitted for that leadership and asked that he might continue his Alaskan work.

No other public official, probably, has had the satisfaction of seeing the country he served develop as did Alaska in the quarter of a century that Geologist Brooks was in charge of the work there. And he was far more than a witness of that growth, he was the one man who contributed most to it. Twenty-four times he made the trip to Alaska, not only as geologist-explorer and administrator of scientific work but also, in 1912 and 1913, as vice-chairman of the Alaska Railroad Commission.

All these years Brooks of Alaska—to give him the name he earned—served this outpost territory as the tireless collector of facts, as the ever-ready source of authoritative information (though never as the propagandist), and above all as the man with an intensely practical vision of the Alaska that is to be. When stricken at his office desk he had just completed, for presentation before the Brooklyn Institute on the following evening, an inspiring address on "The future of Alaska." No man saw that future with clearer vision, no man had a firmer faith in that future, no man did more to lay a sure foundation for that future than Alfred Brooks.

But his loyalty to the Geological Survey and to Alaska was only an expression of his intense devotion to his country. It was America that he loved most and that he invested with high ideals, and he inherited his ideals in both science and patriotism from his father, Major Thomas Benton Brooks, geologist and Union soldier. The military history of his country had been a special study of Alfred Brooks, and it was not a mere passing interest that led to the transmittal in May, 1915, of the Brooks memorandum on a plan for creating a professional reserve corps—a plan which was immediately made the subject of study at the Army War College. Two years later the opportunity came for the second Major Brooks to contribute personally to the military efficiency of his country by putting his engineering ability into service at General Headquarters in France, where from September, 1917, to February, 1919, he acted as chief geologist of the American Expeditionary Forces, receiving the rank of lieutenant colonel in October, 1918. With him, as with so many other true Americans, the well-ordered routine of a career counted for little at that time of stress: his country needed different service, and this he gave without hesitation. Above all else Colonel Brooks was loyal to America.

On the completion of 25 years of federal service a congratulatory telegram was sent to Brooks, then in Alaska. His characteristic reply, from which I quote in closing this memorial, tells lightly yet seriously and modestly of his life work. Those who knew him well can read much between those lines written from Anchorage in August, 1919:

> Were the day clear I could see Mt. McKinley from the window. As I picture in my mind its stupendous height, I compare it to our science. Many have assailed its flanks; some have proclaimed untruths about it; some have climbed by great effort well up the slopes; a very

[1] Presented at the meeting of the Geological Society of America at Ithaca, on December 29, 1924.

few, the best by natural selection, have reached the summit and there attained the broad vision denied those at lower altitudes. As for me, I am satisfied to have been able to traverse the great lowland to the base, and to climb the foothills.

GEORGE OTIS SMITH

U. S. GEOLOGICAL SURVEY

SCIENTIFIC EVENTS

APPLIED SCIENCE AT THE UNIVERSITY OF BRUSSELS[1]

THE highly successful celebrations in connection with the fiftieth anniversary of the founding of the Applied Science School of the University of Brussels were held in the latter half of November, and were attended by the King of the Belgians, who received the foreign delegates, and also by the Duke of Brabant, who laid the foundation stone of a new building which will continue the development of the university. The city of Brussels and private donors have contributed largely to this scheme, as also the American Committee for the Relief of Belgium. Great progress has been made in the buildings for pure and applied science at Solbosch, on the outskirts of Brussels, where, with ample space at disposal, it has been possible to erect a very fine block of buildings in the form of a hollow square.

Physics and chemistry are very well housed and equipped, and especial care has been taken to provide a number of small rooms for research work. The electrical engineering laboratories are remarkably well planned, and especially so as regards the arrangement of their numerous power circuits, which are carried round the walls below the windows and are protected by wire grillages. These circuits are connected to a number of panel units also completely enclosed and provided with the usual resistances, switch gear and measuring instruments all connected up in such a manner that students can readily trace out the various circuits, to which access is gained by numerous doors.

The main laboratory for investigating the strength and other physical properties of materials is chiefly notable for a fine equipment of Amsler testing machines housed in a spacious room provided with an overhead crane, and there are also a considerable number of accessory instruments for measurement and calibration work. A special photo-elastic laboratory is also arranged for in connection with this department.

The laboratories for technical thermodynamics and hydraulics are now in course of equipment and are on a large scale typical of continental views of such matters, and, like the other laboratories, have well-lighted basements with considerable head room, an arrangement which is especially convenient for steam plants and machinery dealing with the flow of liquids.

In connection with the celebrations, a number of scientific and technical addresses were given, and numerous other functions were arranged by the government, the university and the civic authorities.

[1] From *Nature*.

ANNUAL EXHIBITION AT THE CARNEGIE INSTITUTION OF WASHINGTON

THE annual exhibition of the results of recent research activities of the Carnegie Institution of Washington was opened to the public for a few days beginning December 13. The exhibits were also retained intact in the administration building of the institution throughout the Washington meetings of the American Association for the Advancement of Science as a part of the exhibit program of the local committee of the association.

In this exhibition no attempt was made to include materials representative of all research work of the institution, but effort was directed toward presentation of a visual story of major research accomplishments of the past year. In this way it is hoped that recurrent exhibits may illustrate the latest results of continued research as an aid in the dissemination of information concerning progress of work of the institution, and may serve as a stimulating means to more effective cooperation among investigators connected with the institution and with other research organizations.

The success of the exhibition was due largely to demonstration and explanation by the scientists whose work was represented, or by qualified attendants. Attention may be directed to the following exhibits which related especially to the results of most recently undertaken investigations:

Demonstration of a new modification of respiration apparatus to determine the heat of combustion or the energy in different kinds of food. This apparatus was demonstrated by Dr. F. G. Benedict and Mr. E. L. Fox of the Nutrition Laboratory.

Dr. A. H. Schulz, of the department of embryology, exhibited some interesting charts showing variability in human body proportions in illustration of his conclusion that environment plays very little part in such development.

The Geophysical Laboratory, Dr. A. L. Day, director, presented a model composition of the earth, a new microscope furnace for use with high magnification, a new model illustrating sinking of crystals in a laboratory crucible and in natural molten rock, a spectrographic method for determination of metallic constituents in volcanic materials, and a new gravity balance recently devised by Dr. F. E. Wright.

Among exhibits of the Mount Wilson Observatory were shown the operation of a vacuum thermocouple for measuring planetary temperatures and the new seismograph for detecting earthquakes, the latter recently developed by Dr. J. A. Anderson.

The department of terrestrial magnetism presented an interesting exhibit of methods and equipment developed and used to record and measure earth currents.

Dr. S. G. Morley and his associates, who have been carrying on archeological investigations in British Honduras, Guatemala and Mexico, showed the progress of these investigations by means of maps, photographs and models.

Among the exhibits representing work of research associates should be mentioned the apparatus developed by Dr. B. E. Livingston and Mr. J. D. Wilson showing the influence of conditions such as wind and light on rate of water-loss from plants. The thoroughly developed technique and the convincing operation of this apparatus proved a source of much interest.

Interesting exhibits were also on view from other research departments of the institution and from other research associates, including Dr. Albert Mann, Dr. Ralph W. Chaney, Dr. T. W. Richards, of Harvard University, Dr. T. B. Osborne and Dr. L. B. Mendel, of the Connecticut Agricultural Experiment Station and Yale University, and Dr. A. E. Douglass, of the University of Arizona.

RESEARCH PRIZE AT THE UNIVERSITY OF VIRGINIA

To encourage scientific research at the University of Virginia, the President and Visitors' Research Prize has been established through a gift of Hollis Rinehart, member of the board of visitors, in the form of $100 in gold, to be awarded each year for the best original investigation published by a professor or student of the university.

This award is to be announced each April at the annual meeting of the local chapter of Sigma Xi.

Selection of the winner of the President and Visitors' Research Prize will be made by a committee of authorities selected by Dr. F. K. Richtmyer, national president of Sigma Xi and professor of physics at Cornell University. The names of the committeemen have not been announced.

Heads of each of the scientific departments of the university will select the most suitable published research from his department each year and will present it to the committee of Sigma Xi. The prize is not limited to any one field but is open to investigators in pure and applied science and mathematics. Competition is limited to the schools of astronomy, biology, chemistry, geology, mathematics, physics and to the departments of engineering and medicine.

First award of the President and Visitors' Research Prize will be made at the next annual meeting of Sigma Xi in April. Dr. S. A. Mitchell, professor of astronomy and director of the Leander McCormick Observatory, is president of the local chapter. The winner of the prize will be asked to address members of the faculty on his subject in the following fall.

Need for such a recognition of original investigation at the university has long been felt and the organization of the local chapter of Sigma Xi in 1923 followed the appointment of a faculty committee on research. The two bodies cooperating worked out the plan for the President and Visitors' Research Prize.

THE FORMATION OF THE AMERICAN SOCIETY OF PARASITOLOGISTS

A NEW society, the American Society of Parasitologists, was formed at a meeting of a number of those interested in parasitology held in Washington on December 30, 1924. As stated in its constitution the object of the new society shall be the association of workers in the field of parasitology for the presentation and discussion of new or important facts and problems in that science and for the adoption of such measurers as shall tend to the advancement of parasitological teaching and investigation in this country. The members of the society are to be of two classes, active and foreign honorary and any person interested in parasitology shall be eligible for active membership. The dues of the society were set at one dollar a year. The following officers were elected for the first year:

President, H. B. Ward.
Vice-president, S. T. Darling.
Secretary-Treasurer, W. W. Cort.
Members at large of the Council:

For one year.	For three years.
F. C. Bishopp,	R. W. Hegner,
C. A. Kofoid.	B. H. Ransom.
For two years.	**For four years.**
W. A. Riley,	P. S. Bartsch,
E. E. Tyzzer.	C. W. Stiles.

The secretary-treasurer will be glad to receive applications for membership accompanied by the dues for the first year. Also, the council will be glad to receive suggestions from any one interested in regard to the policies or activities of the new society.

W. W. CORT,
Secretary-Treasurer
SCHOOL OF HYGIENE AND PUBLIC HEALTH,
JOHNS HOPKINS UNIVERSITY

APPALACHIAN FOREST RESEARCH COUNCIL

AN Appalachian Forest Research Council has been appointed by Secretary Gore, of the U. S. Depart-

ment of Agriculture. The purpose of the council is not to conduct research work itself, but to stimulate and to coordinate the efforts of all agencies in the Appalachian region engaged in forest research, and to advise them in the selection of the problems to be undertaken. The council will serve also as a connecting link between the technical forest research on the one hand and the public, wood-using industries and other interested agencies on the other.

Twenty-two individuals have been appointed on this council representing the universities and agricultural colleges in the region, state foresters, timberland owners and operators, forestry associations, lumber trade papers and the railroads.

Among those appointed by Secretary Gore are: Dr. W. J. Hutchins, president of Berea College; Dr. B. W. Kilgore, dean of the North Carolina Agricultural College; J. F. Lakin, president of the West Virginia State Board of Control; S. F. Horn, editor of the *Southern Lumberman,* and F. W. Besley, state forester of Maryland.

SCIENTIFIC NOTES AND NEWS

DR. AUGUSTUS TROWBRIDGE, professor of physics at Princeton University, has resigned to take the European directorship in pure science of the International Education Board.

DR. W. J. V. OSTERHOUT, professor of botany at Harvard University, gave the third William Thompson Sedgwick memorial lecture of the Massachusetts Institute of Technology on January 23. The subject of the lecture was "Some fundamental problems of cellular physiology."

PROFESSOR JEAN LOUIS FAURE has been elected a member of the French Academy of Medicine in the section of surgery.

PROFESSOR E. GOURSAT, of the faculty of science of the University of Paris, and Professor L. Bianchi, professor of analytical geometry in the University of Pisa, have been elected associates of the section of mathematical and physical science of the Belgian Royal Academy.

THE Huxley Memorial Medal for 1924 of the Royal Anthropological Institute was presented to Dr. René Verneau, of Paris, at a meeting of the institute held on November 25.

THE Foulerton Award of the Geologists' Association will be presented to A. L. Leach, honorary secretary of the association from 1913 to 1918, at the annual general meeting to be held next February.

DR. G. HABERLANDT, professor of plant physiology at the University of Berlin, celebrated his seventieth birthday on November 28.

DR. FRANZ MERTENS, emeritus professor of mathematics at the University of Vienna and corresponding member of the Academy of Sciences of Berlin, has celebrated the sixtieth anniversary of his doctorate.

DR. G. A. DEAN, professor of entomology at the Kansas State Agricultural College, was elected president of the Entomological Society of America at the recent Washington meeting.

DR. FREDERIC S. LEE, research professor of biology in Columbia University, has been reelected president of the board of managers of the New York Botanical Garden.

DEAN HUGO WINKENWERDER, of the college of forestry at the University of Washington, has been appointed chairman of the educational committee of the Society of American Foresters, in succession to Dr. H. S. Graves, of the Yale Forestry School.

PROFESSOR A. E. WHITE, of the Engineering College in the University of Michigan, has been appointed to a position on the research committee of the American Society of Mechanical Engineers.

AT the annual meeting of the board of regents of the Smithsonian Institution, Senators Smoot and Pepper were appointed to fill the vacancies on the board caused by the death of Senator Lodge and the resignation of Senator McCormick.

THE Earl of Balfour, F.R.S., and the Right Hon. William Graham, LL.B., M.P., have been appointed into the vacancies in the membership of the Medical Research Council caused by the retirement of the Right Hon. Edward Wood and Mr. A. G. Church. Lord Balfour has accepted the chairmanship of the council.

DR. G. T. MORGAN, F.R.S., professor of chemistry in the University of Birmingham, has been appointed superintendent of the new chemical research laboratory of the Department of Scientific and Industrial Research at Teddington.

MURRAY MACGREGOR, district geologist, has been appointed assistant director of the Geological Survey in Scotland in succession to Dr. Walcot Gibson, who retired on January 3.

FOLLOWING the relinquishing by Dr. R. K. Young of his position in the Dominion Astrophysical Observatory at Victoria to become associate professor of astronomy in the University of Toronto, J. A. Pearce, fellow at the Lick Observatory, has been appointed astronomer at Victoria. Harold F. Balmer, demonstrator in astronomy at the University of Toronto, has been appointed assistant in the Lick Observatory.

W. J. GELDARD has resigned from the National Bureau of Standards to accept a position as director

of the division of control and testing of the Fisk Rubber Co., Chicopee Falls, Mass.

MARCUS A. GROSSMAN, formerly chief metallurgist of the Atlas Steel Co., New York, has been appointed director of research, United Alloy Steel Corporation, Ohio.

DR. EMIL G. SCHMIDT, Ph.D., Wisconsin ('24), has accepted a position as research chemist with the Commercial Solvents Corporation, Terre Haute, Indiana.

FRANKLIN B. HANLEY, instructor in geology at Washington University, St. Louis, has joined the staff of the McGraw-Hill Book Company, as traveling college representative.

DR. WILLIAM M. MANN returned recently from an extended trip, in the interests of the Federal Horticultural Board, to southern Europe where he investigated the distribution of the Mediterranean fruit fly.

A CORNELL UNIVERSITY faculty party consisting of Professor John H. Comstock, Mrs. Comstock and Professor Simon H. Gage, recently sailed from San Francisco aboard the *President Hayes,* bound on a trip around the world.

SIR DANIEL HALL, chief scientific adviser to the Ministry of Agriculture, England, sailed from Liverpool on January 10, for the United States, where he is going to consult with officials concerning matters connected with agriculture, particularly foot and mouth disease.

THE retiring president of the Philosophical Society of Washington, Dr. Daniel L. Hazard, of the United States Coast and Geodetic Survey, gave an address before the society on January 10, on "Terrestrial magnetism of the twentieth century."

DR. A. L. DAY, director of the Geophysical Laboratory and retiring president of the Washington Academy of Sciences, gave an address before the academy on January 13, on the subject of "The study of earth movements in California."

DR. WILLIAM J. GIES, professor of biochemistry at Columbia University, gave a lecture on "The teeth from the standpoint of a biochemist" at Jefferson Medical College on January 19.

DR. W. O. RICHTMANN, assistant professor of pharmacognosy and pharmacognist of the Pharmaceutical Experimental Station, Wisconsin, addressed the Chicago Branch of the American Pharmaceutical Association on January 9 on "Camphor."

DR. LAUGE KOCH, of the University of Copenhagen, gave a popular illustrated lecture, "Exploration in northernmost Greenland," before the Natural Science Society of Princeton University on the afternoon of January 8. The same evening he lectured before the Geology Club of the university on "The geology of northwestern Greenland."

DR. C. A. SCHENCK, of Darmstadt, Germany, founder of the Biltmore Forestry School in North Carolina, spoke before the Massachusetts Forestry Association in Boston on January 17.

ON December 20, Dr. A. G. Huntsman, director of the Atlantic Marine Biological Stations, Halifax and St. Andrews, delivered an address to the Royal Canadian Institute on the subject "The ocean around Newfoundland."

PROFESSOR J. L. MYERS gave his presidential address before the Geological Association, meeting in London, on January 2, on a "Geological view of the historical methods in ethnology."

DR. DANIEL STROBEL MARTIN, formerly professor of geology at Rutgers Female College, New York, died on January 4, aged eighty-three years.

COLONEL MALCOLM CRUMP, geologist and for many years professor in Ogden College, died on January 14, aged seventy-five years.

RICHARD IRWIN LYNCH, who for forty years was curator of the University Botanic Garden, Cambridge, died on December 7, aged seventy-four years.

PROFESSOR FRANZ SCHRADER, formerly of the School of Anthropology in Paris, eminent French geographer, died recently in his eightieth year.

DR. ADOLF VON STRUEMPELL, senior member of the medical faculty of the University of Leipzig, died on January 9, aged seventy-one years.

DR. OTTO PUFAHL, professor of metallurgy in the mining department of the Berlin Technische Hochschule, died on November 18, aged seventy years.

THE 195th meeting of the Washington Academy of Sciences was a joint meeting with the Anthropological Society, the Archeological Society and the Biological Society. It was held at the Carnegie Institution of Washington, on January 20. The program consisted of a symposium on: "The origin and evolution of man," with addresses by Dr. J. C. Merriam, of the Carnegie Institution, Dr. A. Schultz, of the Carnegie Institution, and Dr. A. Hrdlička, of the U. S. National Museum.

THE Physical Society of Pittsburgh has had recent lectures on "The Allegheny Observatory results on the shift of spectral lines predicted by the theory of relativity," by Dr. K. Burns; "Radium and radon," by Dr. C. Viol, and "The optical properties of metallic crystals," by Dr. L. P. Sieg. The officers of the society are: *President,* Dr. L. O. Grondahl; *vice-presi-*

dent, Dr. H. D. Curtis; *secretary-treasurer,* Dr. R. J. Piersol.

AT a meeting of the Science Section of the Association of Colleges and Preparatory Schools of the Middle States and Maryland on November 28 and 29 the following officers were elected: *President,* W. B. Meldrum, professor of chemistry, Haverford College; *vice-president,* W. J. Hancock, Erasmus Hall High School, Brooklyn, N. Y.; *secretary-treasurer,* Miss Elizabeth W. Towele, the Baldwin School, Bryn Mawr, Pa.

FREE lectures and demonstrations are being given in the Central Display Greenhouse, at the New York Botanical Garden, as follows: January 3, "Christmas trees from other lands," Mr. K. R. Boynton; January 10, "Ferns of the tropics," Dr. M. A. Howe; January 17, "Illustrations of rare plants grown by the garden," Mr. K. R. Boynton; January 24, "Some plants concerned in the formation of coal," Dr. Arthur Hollick; January 31, "Variegated plants," Dr. A. B. Stout; February 7, "Cacti," Dr. J. K. Small; February 14, "House plants and their care," Mr. H. W. Becker; February 21, "Tropical orchids," Dr. H. A. Gleason; February 28, "The history and development of greenhouses," Dr. J. H. Barnhart.

IT is announced by the secretary, Dr. Henri Abraham, that the International Physical Union will hold its next meetings at Brussels, in July.

MEASUREMENTS of natural light during the total eclipse of the sun, January 24, are to be taken by six coordinated expeditions of members of the Illuminating Engineering Society and members of Yale University and other laboratories. Each of the expeditions will attempt determinations during totality of the illumination produced by the sun's corona, of the brightness of the sky and the horizontal illumination at the point of observation. An expedition from the University of Toronto and the Toronto chapter of the Illuminating Engineering Society will make photometric measurements in the neighborhood of Hamilton, Ont., another expedition from Cornell University in the neighborhood of Ithaca, N. Y., and a third from Yale University in the vicinity of New Haven. Three expeditions from the Electrical Testing Laboratories of New York will take measurements in the neighborhood, respectively, of Newburgh, N. Y., Danbury, Conn., and Greenport, L. I.

THE Brigham Young University of Provo, Utah, has had turned over to it by the U. S. Forest Service 53 acres of land in the Wasatch National Forest which the institution will use for scientific study and experimental work in connection with its Alpine Summer School which is conducted for a period of six weeks each summer on Mt. Timpanogos at an elevation of nearly 7,000 feet. The land adjoins a tract owned by the university on which dormitories, dining-halls and similar buildings were erected two years ago.

THE library and collection of plants belonging to Mr. J. P. Anderson, Juneau, Alaska, were totally destroyed by fire on November 12, 1924. Mr. Anderson is a student of the Alaskan flora, and he had in preparation an account of the rusts of that region.

THE Rockefeller Foundation has appropriated $350,000 to help finance the new abstract journal, *International Biological Abstracts,* which is to give monthly abstracts of all publications in the fields of botany, zoology, bacteriology and related subjects. This sum will take care of editorial and office expenses for ten years, so that subscriptions will need to support only the actual costs of printing and distribution. Publication will begin in January, 1926.

DR. CHARLES H. MAYO has given money to endow a lectureship in surgery at Northwestern University Medical School.

J. J. LISTER has presented to the University of Glasgow the microscope used throughout his life by his uncle, Lord Lister, together with a number of auxiliary appliances and mounted preparations. The relics will be placed, with the microscope of William Hunter, in the Hunterian Museum.

THE London *Times* states that after a long discussion the Swedish Academy of Sciences has decided not to award the Nobel Prizes for chemistry and physics for 1924, but to reserve them another year.

AT a recent meeting of the Industrial Research Council of Canada, held at Ottawa, the question of a national research laboratory at Ottawa was discussed, and the announcement made that some action would be taken at the coming session of Parliament toward securing a grant for that purpose. This is held to be most essential to the work of the council. During the session of 1921 a bill providing for such an institution was passed by the Commons, but was rejected by the Senate.

AT a meeting of the Royal College of Physicians held on October 30, it was moved for the first time that an alteration in the by-laws be made so as to make it possible for women to be elected to the fellowship. This alteration was approved, but will have to be brought before another meeting of the college before it can be ratified.

AN endowment of $400,000, the largest ever bestowed upon the University of Michigan for purposes

of medical research, has been given to the board of regents by Mrs. Christina MacDonald Simpson, widow of the late Thomas H. Simpson, Detroit manufacturer. The endowment is to be known as "The Thomas Henry Simpson Memorial Institute for Medical Research." The letter of presentation sets forth that $150,000 of the gift shall be devoted to the erection of a building for medical research in conjunction with the university. The remainder is to be invested in securities, the income of which is to be used for payment of salaries of medical and scientific directors and their assistants in the conducting of the research. Mrs. Simpson asks that the research work be devoted primarily to the study of pernicious anemia, the disease of which her husband died.

ANNOUNCEMENT has been made by Dr. Jacob Diner of plans to establish in New York City a national academy of pharmacy, similar to the Academy of Medicine, where pharmacy will be given the dignity of educational and ethical standards it is entitled to enjoy as a specialized branch of medicine. Dr. Diner says: "The new building will have a library to which pharmacists may go for information obtained from books not owned by most pharmacists. The library will be in charge of competent persons who will assist in getting the desired information. There will be magazines of interest to the profession. Scientific lectures by pharmacists of note will be given, and there also will be public lectures on hygiene and sanitation and the use and abuse of drugs. Persons desiring information can telephone the library with certainty of obtaining reliable information. Since the law officially recognizes pharmacy as a profession, the members of the profession feel that those who are unqualified and who do not think of public service should be driven from the profession."

IN connection with the new engineering building at the University of Michigan, the department is engaging upon an extensive study of the fundamental properties of cast irons, utilizing the foundry, metallurgical and chemical laboratory facilities provided in the structure. According to *Chemical and Metallurgical Engineering,* the progress made up to the present time indicates that important results will be derived in the endeavor to determine which basic properties are responsible for the different and decided variations in the strength of cast iron. The equipment in the engineering building is suitable for carrying through investigations and experiments in the line of erosion and corrosion resisting cast irons; heat resisting cast irons; malleable cast irons; measurement of melting and pouring temperatures; cupola practice; molding sands; facing sands, and the like. In addition, facilities are available for undertaking investigations on core oils and core binders in general. Along the latter lines, some preliminary research has been made with regard to the properties of commercial core oils, and a definite program is being developed for this work to ascertan a standard test procedure for determining the qualities of same. It is purposed to raise a sufficient fund to carry out this work.

UNIVERSITY AND EDUCATIONAL NOTES

THE General Education Board has contributed $2,000,000 to the endowment of the University of Chicago, on condition that the university raise $4,000,000 additional for the same purpose.

NORTHWESTERN UNIVERSITY has received gifts of $675,000 from anonymous donors. The university embarked in 1920 on a campaign to raise in a ten-year period $25,000,000.

A FERTILIZER school has been opened at Texarkana, Tex., under the direction of experts of the Texas Agricultural and Mechanical College and from the College of Agriculture of the University of Arkansas, Fayetteville, Ark. The initial attendance totals 300 persons from the border counties of the states of Texas and Arkansas.

PROFESSOR KARL T. COMPTON, whose appointment to the department of physics at the University of Chicago was announced in SCIENCE last spring, has been released from the appointment, owing to the situation created in Princeton University by the resignation of Professor Trowbridge, and will continue his work of directing research in physics at Princeton. Professor W. F. Magie has resigned from his position as dean of the faculty and will continue his active work as head of the department of physics. Professor Howard McClenahan, who has been dean of the college, has been granted leave of absence from Princeton University for the coming year, and will, on his return, resume his work in the departments of physics and electrical engineering.

DR. E. D. FRIEDMAN, who is attached to the staff of Bellevue and Mt. Sinai hospitals, has been appointed clinical professor of neurology in the medical department of New York University.

DR. FRANKLIN G. EBAUGH, director of the department of neuropsychiatry at the Philadelphia General Hospital, has resigned to accept a position as professor of psychiatry at the University of Colorado, and director of the Colorado Psychopathic Hospital, Denver.

P. F. SHANNON, division superintendent for the Mutual Oil Company, has accepted a position as as-

sistant professor of petroleum engineering at the Colorado School of Mines.

JAMES MONTAGU FRANK DRUMMOND, director of research for the Scottish Society for Research in Plant-breeding, has been appointed Regius professor of botany in the University of Glasgow, in the room of Professor Bower, who has resigned.

DR. WILHELM EITEL, professor of physico-chemical mineralogy and petrography at Königsberg, has been invited to the chair of mineralogy at Freiburg-im-Breisgau.

DISCUSSION AND CORRESPONDENCE

THE POPULATION OF CANADA

MALTHUSIANISM has returned. The discussion of the problem of population is widespread. East's "Mankind at the Crossroads" and the scientific papers by Pearl and Reed now available in Pearl's "Studies in Human Biology" forecast populations or tell us of the dire consequences that may soon ensue. This summer in the Institute of Politics at Williamstown and in the meeting of the British Association at Toronto the problem was thoughtfully discussed. I heard at Toronto G. Udne Yule's clear and sympathetic exposition of the Pearl-Reed curve $1/P = A + Be^{-nt}$ followed by an expression of scepticism on the part of many economists. In conversation it was recalled that according to press reports Lloyd George when in Canada not so many months ago predicted a future population of 300 million for that great dominion. This seemed somewhat extravagant in view of the Pearl-Reed forecast of only 197 million for the United States and I resolved to examine the figures by the method of these scientists to check up on the politician and statesman.

We have had eight censuses in Canada decennially, commencing in 1851. The figures in millions are:

1851	1861	1871	1881	1891	1901	1911	1921
2.38	3.16	3.69	4.32	4.82	5.37	7.21	8.79

By various methods I reached the solution

$$1/P = -.0286 + .3967\ e^{-.0157t}$$

which was checked by Dr. W. J. Luyten of the Harvard College Observatory by treating it as a first approximation to be corrected with a least-squares solution. His result was

$$1/P = -.031 + .430\ e^{-.0155t}$$

t being measured in years from 1851. The solutions look decidedly different, but we must remember that in a minimum problem a considerable variation of the variables (here, A. B, n) may not effectively change the minimum value. For the two equations the fit is in fact equally good. The departures between the observed and the fitted values were in the 8 cases, respectively, about $+5, -6, -5, -4, +3, +10, 0, 0$ per cent., giving a mean algebraic error of less than one half per cent. and a mean arithmetic error of 4 per cent. Forecasting from the equations, it appears that about the year 2013 the population of Canada reaches the value 300 million set by Lloyd George.

Further, it appears that on some day apparently in the year 2020 the Canadian population will become infinite.

Dies irae, dies illa!

Somewhat disconcerted by this result I tried to fit the curves

$$P = d + \frac{1}{A + Be^{-nt}}$$

$$P = \frac{k}{1 + me^{at + bt^2 + ct^3}}$$

which are also used by Pearl and Reed when they desire a better fit than that given by the simple 3-constant equation. The last equation has five constants to fit to eight points. The results, however, remained disconcerting.

Solvet sæclum et favilla—

But I am not a good curve-fitter.

Now what, if anything, may these results mean? First, they can not in any way impugn Pearl's biologic postulate that populations must tend to saturation. Canada will never have an infinite population, nor yet 300 millions, nor perhaps more than one fifth of that figure. Second, they do not cast doubt upon his findings that experimental (laboratory) populations do follow his growth curves, nor upon his further demonstrations that human populations (for so long as good censuses have been available) in many cases have followed his curves with a high degree of fidelity and already disclose a tendency to saturation. The results do show, I think, that the Canadian population (and other instances could be given) so far fails to indicate approaching saturation as actually to show a runaway tendency.

And why should this not be so! The Malthusian dictum that population tends to increase in geometric progression whereas food tends to an arithmetic increase really implies in its latter half the economic law of diminishing returns (as applied to agriculture). It would be as silly to doubt this law, which is analogous to that of Chatelier in physical chemistry, as to question the saturation of population or the fact that increasing the pressure diminishes the volume. But all such laws are based upon the under-

lying conception of an (at least approximate) equilibrium, and in fact may be taken as definitions of states of equilibrium. The principle "To him that hath shall be given" is not a definition of equilibrium nor an illustration of the law of diminishing returns!

We have in physical chemistry conditions leading to explosions and in economics we have had for a century similar conditions wherein the law of diminishing returns is in abeyance. Given on the one hand concentrations of population with more or less fixed habits and on the other hand extensive new agricultural territory to bring under cultivation, it is not necessary that more persons to feed should make it harder for all to get food—they may make it easier, for a million new farmers in Canada may supply not only themselves but from their surplus an additional million or more in Europe. Hence the population curve for Canada may well for a time show an explosive rise whether by an unusually large birth-rate or by an eager immigration or by both. Much the same conditions and results may flow from an industrialization; replacing some human labor by the work of tools frees human time for the invention of still more tools to relieve more human labor. The drift to the cities has been another case of "To him that hath shall be given."

Only the unduly optimistic will believe that there is no limit to this sort of process and that the law of diminishing returns will never again be invoked nor the world return to a state approximating equilibrium. In fact, the tendency of most populations to saturation shows that even now and during the past century of feverish development alike of new land and of new machinery, whether of manufacture or of trade, that law has still held general regulatory sway over human increase, although in different populations at different times the sort of variation now shown by Canada has been seen for several decades on end.

Not unlikely Pearl and Reed or Yule may feel that it is pushing the formula pretty hard to carry it over to negative values of A and forced or accelerated instead of retarded populations. I admit it. I have my serious doubts about the applicability of the growth curves to human populations. Some of these doubts I have taken up in a paper (with Dr. W. J. Luyten) for the autumn meeting of the National Academy of Sciences. There is no good theoretical foundation for the curves. The simplest one $1/P = A + Be^{-nt}$, used above, is the law of autocatalytic reaction and as such was suggestive to biochemists relative to growth of organisms—children, tree shoots, etc. The analogy between an autocatalytic reaction and a living organism is not good, nor particularly bad, but the curve fits the growth of an organism tolerably well. The analogy between an organism and a society has its weak and its strong points; the curve still fits tolerably and in some cases surprisingly well.

There are analytical reasons that may be adduced to favor the curve within certain limits; this was, if I recall correctly, the point of view taken by Yule at Toronto. If it be admitted that the rate of growth of a population or organism at any time is dependent chiefly on its size at the time we have

$$\frac{dP}{dt} = f(P) = a_0 + a_1P + a_2P^2 + \ldots,$$

where $f(P)$ has been expanded into a Maclaurin series. Now as there is no growth with $P = 0$ we infer $a_0 = 0$. A first analytic approximation is

$$\frac{dP}{dt} = a_1P \text{ or } P = P_0e^{at}$$

which is the Malthusian law of geometric growth. If we retain two terms

$$\frac{dP}{dt} = a_1P + a_2P^2,$$

and with a_2 negative we have the autocatalytic law with a limiting population of $L = -a_1/a_2$, a growth retarded by the law of diminishing returns, by Malthusian checks of some sort. It is however analytically possible to consider the case where a_2 might be positive and the growth is accelerated; the solution is then of the form found above for Canada, but, as the condition is unstable, terms of higher order in P must ultimately come in to check the growth and lead to the stability of saturation.

Another way to put the analytic argument is this: The function $f(P)$, since it vanishes when $P = 0$, may be written as $f(P) = P\Phi(P)$. If there is to be saturation $f(P)$ and $\Phi(P)$ must also vanish when $P = L$, the limiting population. Hence we may write $f(P) = P(L - P)\Psi(P)$. Then expanding $\Psi(P)$ we have

$$\frac{dP}{dt} = P(L - P)\ (a_0 + a_1P + \ldots).$$

The first approximation is to stop with the first term a_0 and the autocatalytic law. A second approximation would leave the term a_1P_1; then if a_1 is positive and greater than a_0/L there will be an initial explosive growth followed by saturation. A purely analytic argument is, however, not worth very much —it shows possibilities rather than actualities—and is here adduced merely to show that the apparently disconcerting results for Canada do fit into the same sort of analytic system as satisfactory results obtained for other populations. This is fortunate if

there are as there may well be cases of temporary explosions of population growth.

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HAPLOID MALES IN PARACOPIDOSOMOPSIS

SEVERAL years ago one of us (Patterson, 1917)[1] called attention to the fact that in certain species of parasitic Hymenoptera a majority of their polyembryonic broods are mixed, that is, contain both males and females. In a species showing polyembryonic development we should expect to find all the individuals belonging to one sex, provided the entire brood is derived from a single egg. One of the most striking cases of mixed broods is seen in Paracopidosomopsis floridanus (Copidosoma truncatellum). About 87 per cent. of the broods of this species are mixed, and a majority of such broods have less than 6 per cent. of males. In one case a single male was found in a brood of 1,550 individuals.

The rule among polyembryonic species is that the fertilized egg produces females, while the unfertilized egg develops into males. The usual explanation offered to account for the appearance of a mixed brood is that it has come from two (or more) eggs, one of which is unfertilized. In dealing with the data on the sexes of the species under consideration, the senior writer pointed out the difficulty of applying this hypothesis, and suggested that a mixed brood might arise from a fertilized egg during the early cleavage stages, by the loss of a sex chromosome in one or more blastomeres. Such a blastomere would have the diploid-minus-one number of chromosomes and might give rise to a group of males. It was further pointed out that this suggestion could be tested out by making a cytological study of the germ cells of the males appearing in mixed broods. For several years we attempted to secure the necessary material for such a study, but not until last fall (1923) did we succeed in obtaining favorable preparations.

The object of this note is to record the results of our observations. We find that the males from mixed broods possess the haploid number of chromosomes, and not the approximate diploid number. The spermatogenesis in these males is identical with that in males reared from unfertilized eggs (Patterson and Porter, 1917).[2] Our observations leave no doubt as to the fact that males in mixed broods are haploid, and this is true even in broods showing a very low percentage of males.

While the discovery of these facts settles the question of the number of chromosomes in males in mixed broods, it does not, however, definitely determine the manner of origin of mixed broods. To some it might seem to indicate that all mixed broods are to be explained on the two-egg hypothesis, but there are several facts in the development, at least of Paracopidosomopsis, that are difficult to explain on such a basis. Chief among these are (1) the appearance of asexual larvae, and (2) that while a pure male brood reared from an unfertilized egg is about as large as a pure female brood, yet if the unfertilized egg is associated with a fertilized egg in the same host it produces a few males only—sometimes but a single individual.

For the final solution of some of these problems we must look to the study of some of the more primitive polyembryonic species, such as that studied by Leibly and Hill, 1923.[3]

J. T. PATTERSON,
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AUSTIN, TEXAS

AN ANATOMICAL SPELLING MATCH

WHEN the freshman begins his work in the anatomy laboratory he frequently fails to grasp the importance of using all possible channels for gaining the necessary anatomical information, and frequently the story of the test given Vesalius, in Paris, has been described to the students. Richardson, in his book "Disciples of Aesculapius," tells that Vesalius "was closely blindfolded. Then every bone of the body that could be distinguished by the touch was put into his hands and by the sense of touch he was able to name every bone correctly. . . ." Recently, some members of the class asked if they might not try this same test and now two classes have tried this "anatomical spelling match" and so I am passing it on for what it is worth.

The students choose two leaders and they in turn select two groups, thus dividing the class or laboratory section into two teams, as is done in the regular spelling match or in the chemical spelling match, of which so much has been heard lately. The two groups arrange themselves in two rows with their backs towards the opposing sides so that the bones may easily be placed in their hands held behind their backs. This is as satisfactory and takes much less time than blindfolding all the contestants. The one in charge passes down between the two rows and places a bone in the hands of each contestant, one after another, alternately from side to side.

We have found that only one or two men can be

[1] *Biol. Bull.*, XXXII, p. 291.
[2] *Biol. Bull.*, XXXIII, p. 38.
[3] *Jour. Agr. Research*, XXV, p. 337.

eliminated by giving the students the entire bones, and so the second time an assistant holds a watch and each one is given but a very limited time in which to identify the bone. This will eliminate a few more and then we have permitted the contestants to feel only a limited part of each bone and as a final test we have taken bones from the comparative anatomy laboratory and this usually floors more of them, as most of the men have not had a course in comparative osteology. Students who have passed the test are permitted to turn around and thus see what bone is being given to those farther down the line and this makes the test more interesting for all.

This may or may not contribute much in teaching gross anatomy, but it does help to teach the freshman that anatomy and its application in medicine and dentistry requires the training of the fingers as well as the eye. It also helps to stimulate interest in the history of anatomy.

H. B. LATIMER

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HOW MANY FIGURES ARE SIGNIFICANT?

THE discussion of this subject ought to prove interesting to all research workers, teachers and students. It is one of the hard subjects to teach and a harder subject to follow out in practice. The ordinary school boy and girl is usually driven by the teacher to carry out all his calculations in science to an unwarranted extent, the only deciding factor apparently being the number of decimal places. The teacher thinks more of the accuracy of the arithmetic than of the truth of the statement. It takes a long time in the university to replace these ideas (or lack of ideas) in the student's head by a little of the common sense of the theory of measurements. The research worker trained without a course in this subject often wastes his own time and wearies the patience of his readers with an absurd number of "significant" figures in his numerical work. Professor Kelley has done well in calling for a statement on definite and uniform practice. As a mere tyro in this subject and one whose experience lies largely with elementary students I should be inclined to use less significant figures than Professor Kelley. Unless the variates follow the Gaussian Law of Error, and in practice this is rarely the case even when a large number of variates are used, I do not like to quote results with more than a two figure probable error or standard deviation. I don't think the results warrant a greater accuracy than this. In Professor Kelley's first case (SCIENCE, Dec. 5, 1924, p. 524) I should say Mean = 82 and standard deviation 13; in the second case, Correlation coefficient .75 and its probable error .02. In the second case I give only one significant figure to the probable error because of the variation likely to occur in another independent calculation of the correlation coefficient from a different but equally reliable set of data.

JOHN SATTERLY

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LABORATORY APPARATUS AND METHODS

STAINING PARAMECIUM IN THE CLASS-ROOM

A VERY simple, inexpensive and practical method of showing trichocysts, cilia and nucleus of Paramecium was recently demonstrated to students of general biology by the writer, through the application of two different colored inks to the slide of living material.

One or two drops of solution containing the culture is placed on each student's slide, and time is allowed for the study of specimens in their usual activities. When the trichocysts and cilia are to be observed and compared the cover-slip is removed, and a dab or two of Sanford's red ink is carefully stirred into the culture by means of a tooth-pick or pin-head. The slip is then replaced. The swimming and "tumbling" of the slightly opalescent specimens are more pronounced. In about four minutes a fountain-pen containing Waterman's blue ink is applied to the edge of the cover-slip. One can see the expulsion of the trichocysts when the animal plunges into the encroaching wave of blue. In a flash the cytoplasm turns a deep red with purplish tinge, the cilia a flame color and the trichocysts a deep blue—without disruption of the specimen. Various shades may be obtained by the students, depending upon the amount of inks used, and the length of time allowed before applying the blue. Incidentally, the nucleus takes on a more concentrated hue than does the surrounding cytoplasm.

This method can be employed by the students themselves and can be repeated several times during the laboratory period with generally uniform success.

C. R. HALTER

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SPECIAL ARTICLES

TRYPARSAMIDE TREATMENT OF AFRICAN SLEEPING SICKNESS[1]

THE problem of sleeping sickness in tropical Africa is a source of great concern. The disease is be-

[1] From the laboratories of the Rockefeller Institute for Medical Research, New York.

coming more common in many regions long known to be affected and is spreading to regions previously supposed to be free. There are two ways known of combatting the disease: The destruction of breeding places of the tsetse-fly which is the intermediate host of the trypanosome parasite which incites the disease, and the cure of persons already suffering from it. The former undertaking is formidable in a tropical country only sparsely settled and, as yet, very little brought under control of Europeans with knowledge of sanitary measures and power to put them into force. At best, a long period of years must elapse before effective beginnings in that direction can be made.

The actual cure of the disease by means of drugs is something within present possibility. It may be conjectured that by this means the number of infections may be reduced through diminution of sources from which the tsetse-flies become contaminated. One speaks circumspectly upon this point since it still remains unknown whether wild animals serve as reservoirs for the trypanosoma *gambiense*.

Laboratory experiments covering the years 1914 to 1917 led to the production at the Rockefeller Institute for Medical Research of tryparsamide (the sodium salt of N-phenylglycineamide-p-arsonic acid) by Jacobs and Heidelberger (1) and to the determination of its biological action by Brown and Pearce (2). The promising curative results obtained in various species of animals infected with pathogenic trypanosomiasis, by Brown and Pearce, led to the application of the drug to the treatment of human trypanosomiasis, or sleeping sickness, in the Belgian Congo in 1920. The cooperation of the Belgian medical officers has made it possible to keep under observation, for upwards of three years, many of the patients treated by us during our visit. In this way we have gained a knowledge of and insight into the manner and duration of action of tryparsamide which otherwise it would have been very difficult, if not impossible, to secure.

In order to arrive at the real value of any drug in the treatment of human trypanosomiasis two conditions of therapeutic action must be fulfilled: First, its direct destructive or trypanocidal effect as determined by the microscopical examination of the blood and of fluid aspirated from lymph glands, and next, the degree of curative action on cases in the advanced or cerebrospinal stages of the disease. The first effect is more easily achieved than is the latter. Atoxyl, tartar emetic, Bayer 205 and other less well-known drugs have been proven to possess trypanocidal action and thus are of more or less value in the early or acute phases of the disease; no drug, unless it be tryparsamide, has shown a marked therapeutic action in the late stages of the affection.

The results of the first clinical investigations with tryparsamide by Pearce (3), based upon the treatment of 77 patients in Léopoldville, Belgian Congo, demonstrated that tryparsamide caused (1) a prompt disappearance of trypanosomes from the blood and lymph glands, (2) a rapid improvement of the abnormal cerebrospinal fluids of advanced patients which in the majority of cases amounted to a restoration to normal, and (3) a marked improvement of both physical and mental states. Van den Branden and Van Hoof (4), who have continued the observations and treatments in Léopoldville, reported in October, 1923, the condition of 55 patients first treated three years previously. The period of observation after treatment extended from six months to two years and seven months. Twenty of these patients were early cases with normal cerebrospinal fluids; all were alive and in good health when last seen with negative blood, lymph gland and spinal fluid examinations. Thirty-five patients were advanced cases of various types, including several with pronounced lethargy. Three very advanced patients had died. Thirty-two patients were alive and well with negative blood and lymph gland examinations; in 16 the spinal fluid was normal while slight abnormalities persisted in the others. The amount of tryparsamide administered to this group of patients varied greatly under the conditions governing the early investigations and ranged from 2.0 to 82.0 grams. In the light of our present knowledge, however, it appears that many of these patients were insufficiently treated so that the excellent results obtained are all the more striking.

A second group of patients treated with tryparsamide by Chesterman (5) working at Yakusu, near Stanleyville in the Belgian Congo, has recently been reported. The therapeutic results obtained are of special significance because all of his cases were well advanced in the latter stages of the disease and the amount of drug administered was limited, while the period of observation following treatment extends from 18 months to two and one-half years. Only a single course of treatment was given consisting of 8.0 to 27.0 grams. Chesterman reports that 15 out of 37 patients, or 40.5 per cent., have remained well and without sign of relapse for periods averaging over two years from the end of treatment, and he expresses the opinion that the failures were due in many instances to faulty or insufficient dosage. The physical and mental improvement of Chesterman's patients was marked, as was the case with the Léopoldville group.

Only preliminary reports are at present available from the French physicians now using tryparsamide in Africa. Letonturier, de Marqueissac and Jamot

(6), who have reported on 14 patients treated in the Cameroons, are most impressed with the action of the drug in advanced patients and state that to their knowledge no other drug is endowed with such a power of meningeal penetration or has such a beneficial effect upon the clinical symptoms of advanced patients.

In New York City two Americans in the advanced stages of sleeping sickness have been successfully treated with tryparsamide. One patient, whose history has recently been reported by Morgan (7), had relapsed 2 months after treatment with Bayer 205 with the typical symptoms of an advanced infection including lethargy; her condition was extremely grave. Tryparsamide was administered intravenously in three courses over a period of 13 months and she has been given a total amount of 63.0 grams. Clinical improvement was observed after the initial dose of the drug and by the end of the first course of ten doses both the physical and mental condition appeared normal. Since this time she has resumed her household and social duties which have only been interrupted by the additional treatment administered. Physical examinations have continued to be negative, the last one being 6 months after the cessation of treatment. The condition of the second American was fortunately not so critical. Two courses of tryparsamide amounting to 53.0 grams were administered by Dr. K. M. Lewis (8) with prompt clinical response and a rapid restoration of the normal state of the cerebrospinal fluid. The patient's condition was reported to be satisfactory 10 months later.

From various reports, both published and unpublished, dealing with the therapeutic results obtained with tryparsamide in African sleeping sickness, the system of treatment at present recommended is the administration of 24.0 to 30.0 grams in early cases and from 50.0 to 70.0 grams in advanced cases. The treatment for advanced patients should be given in two or three courses separated by intervals of 2 or more months, and each course should consist of eight to ten weekly doses. The size of the individual dose most frequently used is 3.0 grams and the intravenous route of administration has so far been followed almost exclusively.

Tryparsamide is now being widely used in the Belgian Congo at the request of the Colonial Government, and it has recently been supplied to the British and French colonies in tropical Africa. The results of its use under various conditions of field administration and in different parts of Africa will be published from time to time. The chronic nature of African sleeping sickness and its tendency to relapse are formidable obstacles in obtaining authentic cures and it is the realization of these facts that has led us to emphasize the necessity of continued observation of treated patients for long periods of time. However, if future reports are as encouraging as those briefly summarized above and if the treatment of the native population in infected districts can be carried out on a large scale, it is probable that the control of African sleeping sickness may eventually be accomplished.

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THE PANCREATIC RESPONSE TO CARBOHYDRATE INGESTION

IN the course of studies on the relation of blood sugar concentration to food ingestion, we have been impressed with the variety of responses by the body mechanism for glucose storage. The subjects were healthy students working in the chemical laboratory. The morning meal was taken immediately after the first blood sample was drawn. Analyses were made by the Folin-Wu method.

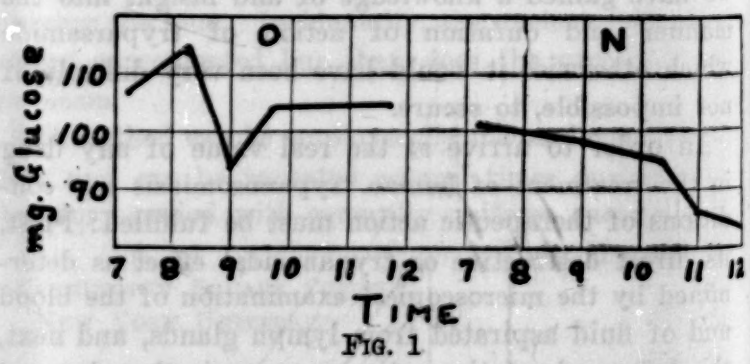

FIG. 1

In Fig. 1 the curve of subject O presents what seems the commonest type of reaction. During the period of relatively low blood sugar concentration there was a definite sense of hunger. This we correlate with the observations reported by Bulatao and Carlson.[1] The curve of subject N is of a different

[1] Bulatao, E., and Carlson, A. J., *Am. J. Physiol.*, 1924, lxix, 107.

type. It is probable that more frequent observations would have shown a brief rise in the curve at first as in O. The steady decrease in the blood sugar for the last three hours is striking. During this period there was marked hunger, relieved for only a few minutes by water-drinking. The most obvious explanation for these observations seems to be the following. The hyperglycemia during food absorption acts as a physiological stimulus to insulin production by the pancreas. The immediate result is glycogen storage and glucose utilization. The insulin thus produced outlasts the need for it. Its presence in greater amount than previous to breakfast leads to the typical hypoglycemia when artificially administered. The hunger is a consequence of the hypoglycemia. The hypoglycemia acts as a physiological stimulus to the glycogenolytic mechanism and the blood sugar returns to the normal "fasting level."[2] This latter level is an optimum operating level for the body in the post-absorptive equilibrium. In some individuals the glycogenolysis may occur at such a slight hypoglycemia that the curve shows it only when frequent observations are made. In others, such as subject O, a definite diphasic curve is found. In still others, such as subject N, the glycogenolysis is a poor response, and hunger gets worse until another meal is taken. N stated that he was not hungry during the morning when he ate no breakfast, but always hungry when he did eat. The reports of Harris[3] seem to be of such individuals.

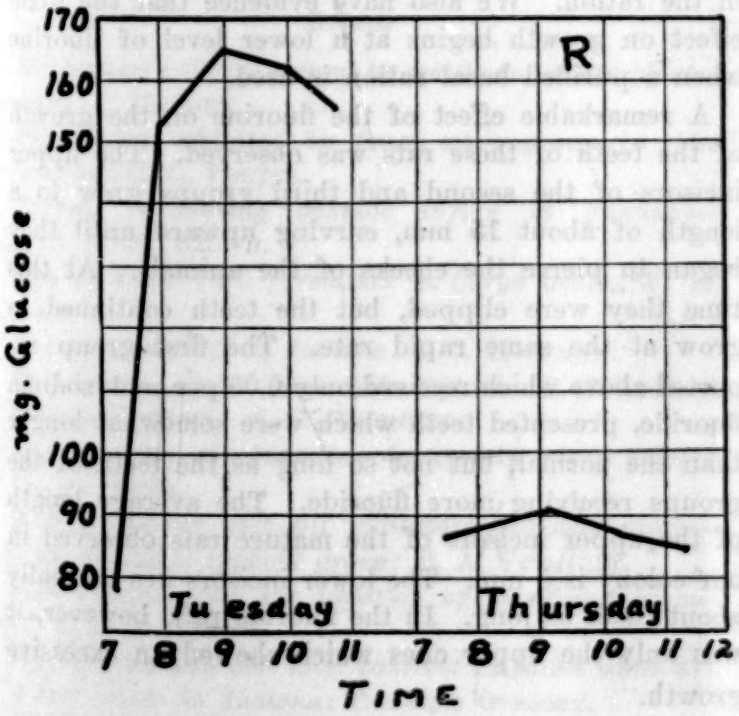

FIG. 2

[2] Cannon, W. B., McIver, M. A., and Bliss, S. W., *Am. J. Physiol.*, 1924, lxix, 46.

[3] Harris, S., *J. Am. Med. Assn.*, 1924, lxxxiii, 729.

In Fig. 2 are shown the results of a somewhat different type of study. R was one of the three students who went on a voluntary three day fast. Blood sugar determinations were made twice on the first and third days. There was a gradual decline in the sugar concentration from 92 mg the first morning to 77 mg the fourth morning. This was not associated with marked hunger. The fast was broken on the fourth morning by a breakfast rich in carbohydrates, including fruit. The blood sugar curve marked "Tuesday" was obtained during this morning. There was a notable lack of satisfaction from the meal until after about two hours afterward. This is to be correlated with the unusually high curve and the marked delay in the return to a normal level. The urine of the last fasting day showed ketosis. Two days later, after meals had been taken as usual, the Tuesday breakfast was repeated exactly, and the blood again analyzed. The curve marked "Thursday" shows a marked contrast to that of the morning after the fast. The Thursday breakfast gave satisfaction subjectively. The two other students studied reacted in this same fashion throughout, except for no evidence of ketonuria. We propose as rapidly as possible to extend these observations and to verify the extent of ketosis. It may be that there is contained here some hint of the nature of the apparently vicious cycle of vomiting and starvation which occurs in pregnancy and after surgical procedures. Insulin has repeatedly been found efficacious in breaking this cycle and restoring normal oxidation without ketosis, when glucose alone failed. These observations may help to explain why in the presence of ketosis it is necessary to use such large doses of insulin to render the diabetic free from glycosuria.

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THE EFFECT OF FLUORINE AS SODIUM FLUORIDE ON THE GROWTH AND REPRODUCTION OF ALBINO RATS

IT has long been known that fluorine is present in the bones and teeth of mammals, and fluorine was used by Osborne and Mendel[1] in one of their salt mixtures for rats more than a decade ago. It is quite generally considered as being one of the inorganic elements essential in nutrition, which is necessary in small amounts only, although there is no evidence of its necessity except its occurrence in the animal body.

[1] Osborne and Mendel, *Journal of Biological Chemistry*, Vol. 15, 317, 1913.

Since rock phosphate generally contains considerable amounts of fluorine, the unfavorable results obtained by Forbes and collaborators[2] at the Ohio station when feeding raw rock phosphate "floats" to swine in comparison with bone products directed suspicion to the fluorine content of the rock phosphate. While some of the unfavorable results obtained in their work may have been due to the considerable magnesium content of the rock phosphate, the occurrence of fluorine in commercial ground phosphate rock adds considerable interest to the results described below, which were obtained in the course of our work on certain inorganic elements in the nutrition of rats.

The toxicity of fluorides has also been studied by several investigators from a pharmacological point of view, using mainly rabbits and dogs. More recently, Sollman, Schettler and Wetzel[3] have fed sodium fluoride to rats in varying amounts, causing progressive impairment of growth and food consumption. Their results agree with those reported here insofar as they are comparable.

The basal ration used in our work was one which was being used in the comparison of other mineral supplements. It consisted of yellow corn 76 parts, meat meal tankage 10 parts, linseed oil meal 10 parts, bone meal 2.5 parts and common salt 0.5 parts. On this basal ration with wood shavings litter the control groups of rats grew at a normal rate and reproduced normally. Sodium fluoride was fed to other groups of rats in the following amounts, mixed thoroughly and ground with the ration: 0.05 per cent., 0.10 per cent., 0.15 per cent. and 0.25 per cent. of the ration.

The rate of growth of the rats in the first fluorine group was normal or better and the animals in this lot remained in good condition after nine months on the ration. There were only two females in this group, but each one successfully produced and reared two litters of young in that time.

The rats in the second group, which received 0.10 per cent. of sodium fluoride, did not grow as well or as rapidly as the first group. The rate of growth of most of the rats in this group was slightly below the normal. Out of six litters of young in this lot four were reared, but these grew at a very slow rate. Both old and young in this lot showed a quite unthrifty appearance, even though the growth of the first generation was nearly at the normal rate. Both the first and second groups produced a third generation, but in the second group the number of young reared was much below the average performance of the controls.

The rats in the third lot, which received 0.15 per cent. sodium fluoride, grew at approximately the same rate as the second group, but out of four litters produced, only two litters lived, to grow at a slow rate. In this lot as in all the sodium fluoride lots, the rats which had been on the ration longest presented the most unthrifty appearance.

In the fourth group, which received 0.25 per cent. sodium fluoride, all the seven rats in the lot died after 8 to 14 weeks on the ration. None of them reached a weight of 100 grams.

The data on the first group, which received 0.05 per cent. sodium fluoride, do not show a performance varying much from the controls on this basal ration, but the observations of the writers lead them to suspect that there was some stimulating effect due to the fluoride, and also that the amount fed was at or very near the maximum possible without showing the ill effects observed in the other groups. Smaller allowances of sodium fluoride have since been tested on the same basal ration.

Amounts of sodium fluoride varying from 0.001 per cent. to 0.25 per cent. of the ration were fed in the second series, with results which corroborate the results just described. No ill effects on growth and well-being are observed until 0.10 per cent. or more of sodium fluoride is fed. A very marked toxic effect is observed when 0.15 per cent. to 0.25 per cent. is allowed in the above-mentioned basal ration. It appears that an unfavorable effect on reproduction begins at a level of about 0.025 per cent. sodium fluoride in the ration. We also have evidence that the toxic effect on growth begins at a lower level of fluorine when a purified basal ration is used.

A remarkable effect of the fluorine on the growth of the teeth of these rats was observed. The upper incisors of the second and third groups grew to a length of about 15 mm, curving upward until they began to pierce the cheeks of the animals. At this time they were clipped, but the teeth continued to grow at the same rapid rate. The first group reported above which received only 0.05 per cent. sodium fluoride, presented teeth which were somewhat longer than the normal, but not so long as the teeth of the groups receiving more fluoride. The average length of the upper incisors of the mature rats observed in our colony is 5 mm. The lower incisors are normally about twice as long. In the fluoride rats, however, it was only the upper ones which showed an excessive growth.

This study of fluorine and its function in nutrition is being continued.

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[2] Forbes, *et al.*, Ohio Agr. Exp. Sta., Bulletin 347, 1921.

[3] Sollman, Schettler and Wetzel, *Journal of Pharmacology and Experimental Therapeutics*, Vol. 17, 197, 1921.

THE INDIANA ACADEMY OF SCIENCE

THE Indiana Academy of Science held its fortieth annual meeting at Purdue University, Lafayette, Indiana, December 4 to 6, 1924.

The following program, including 95 titles, was presented:

Dec. 4—Meeting of Executive Committee.

Dec. 5—General Session.

Business Session at which 108 new members and three fellows were elected.

Stephen Francis Balcom: In memoriam: R. W. MCBRIDE.

Robert Greene Gillum: In memoriam: L. J. RETTGER.

William Allen McBeth: In memoriam: L. J. RETTGER.

John C. Shirk: In memoriam: AMOS BUTLER.

Presentation of papers of general interest.

The research committee of the Indiana Academy of Science: ARTHUR L. FOLEY.

The conservation commission and its work: STANLEY COULTER.

The reported origin of Indian corn from Teosinte: PAUL WEATHERWAX.

City "smogs" in periods of general fair weather: JOHN H. ARMINGTON.

Variations among Indiana counties in land values, roads and death rates: STEPHEN S. VISHER.

Types of errors made in Purdue English test by high school boys: GERALDINE FRANCES SMITH.

President's Address—*Flora of Indiana: On the distribution of the ferns, fern allies and flowering plants:* C. C. DEAM.

SECTIONAL MEETINGS

Botany

Mechanical injuries caused by weeds and other plants: ALBERT A. HANSEN.

Phenomena exhibited by fungi when grown in close proximity: C. L. PORTER.

Factors influencing cyanide injury in greenhouse plants: H. D. BROWN.

Age of scale bark formation in Carya ovata: F. M. ANDREWS.

Vegetable regions of Indiana: I. C. HOFFMAN.

The Purdue garden of medicinal plants: C. J. ZUFALL.

Michikoff wheat: A. T. WIANCKO.

Hydrogen-ion concentration in certain plant juices: F. M. ANDREWS.

Further studies with pH indicators and acid production by the colon typhoid group: P. A. TETRAULT.

Observations upon the isolation of nitrifying organisms: I. L. BALDWIN.

Cabbage diseases and their control: CHARLES GREGORY.

Wheat smuts in Indiana: CHARLES GREGORY.

Observations concerning the disease susceptibility of cereals and wild grasses: E. B. MAINS.

Physiologic specialization in the leaf rust of wheat; Puccinia triticina: E. B. MAINS.

Cladosporium leaf-mold of tomato fruit invasion and seed transmission: MAX. W. GARDNER.

Some rusts of composite life history: H. S. JACKSON.

Indiana plant diseases, 1923 and 1924: MAX. W. GARDNER.

Some new materials that I have found valuable in teaching botany: BLANCHE MCAVOY.

Some ways of stimulating students' interest in botany: C. J. ZUFALL.

A variation of Trillium declinatum: RAY C. FRIESNER.

An unusual Impatiens biflora: F. M. ANDREWS.

The differential staining of fungi in host tissue: E. J. KOHL.

The Uredinales and Ustiliginales of Indiana—IV: H. S. JACKSON.

Recent Indiana weeds, 1924: ALBERT A. HANSEN.

Water hemlock, Cicuta maculata, a biennial in Indiana: ALBERT A. HANSEN.

A preliminary list of lichens of Delaware County, Indiana: BLANCHE MCAVOY.

Notes on Grasses—II: PAUL WEATHERWAX.

Indiana Fungi—VIII: J. M. VAN HOOK.

Further notes on comparative growth in grazed and ungrazed woodlots at Purdue: BURR N. PRENTICE.

Chemistry—Mathematics—Physics

Methods of determining the composition of amalgams: M. G. MELLON.

A note on the behavior of cobaltous hydroxide: LOUIS AGASSIZ TEST.

Farming as a chemical industry: R. H. CARR.

Fertilization of lawns: S. D. CONNER.

Rhythmic crystallization of sodium sulphate in thin agar films: F. O. ANDEREGG and G. W. DAUBENSPECK.

Influence of other elements upon carbon migration in iron and steel: E. G. MAHIN and R. C. SPENCER.

An outline of chemical literature: M. G. MELLON.

A chemical investigation of the water of Devil's Lake, North Dakota: G. A. ABBOTT.

Some suggestions for research in mathematics: WILL E. EDINGTON.

A functional derivation of the area of the triangle: K. P. WILLIAMS.

A special case of a differential equation of infinite order: H. P. DAVIS.

Resonating reflectors for amplifying and directing sound signals: ARTHUR L. FOLEY.

Multiple horns as sound amplifiers: ARTHUR L. FOLEY.

Selective resonance of sound amplifying horns: ARTHUR L. FOLEY.

Photographic method of measurement of per cent. of polarization and some of its applications: B. A. HOWLETT.

Sound waves from explosions: JOHN E. SMITH.

Photography as a means of measuring rate of detonation: JOHN E. SMITH.

Amplification constant of a transformer, principle of the neutrodyne: R. R. RAMSEY.

The effect of ultraviolet light and X-Rays on the stability of matter: ARTHUR L. FOLEY.

The acoustic laboratory room: ARTHUR L. FOLEY.

The formation of alpha rays by simple means: CHARLES P. KNIPP and N. E. SOWERS.